Convection Currents and Fire

Lesson 2 of 2

Grade Level: 9-12
Subject(s): Chemistry
Prep Time: < 10 minutes
Activity Duration: 50-minute class period
Materials Category: Special requirements

National Education Standards				
Science	Mathematics	Technology		Geography
		ISTE	ITEA	
3b, 3c				

Objective:

To conduct an investigation that illustrates the behavior of convection currents.

Materials:

- Large shoe box
- Candle
- Plastic wrap
- Scissors
- Two cardboard tubes
- Paper towels
- Fire-place matches
- Tape
- Clay

Related Link(s):

Microgravity — A Teacher's Guide — EG-1997-08-110-HQ
http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Microgravity/Microgravity.Teachers.Guide.pdf

NASA's Infrared Processing and Analysis Center
http://sirtf.jpl.nasa.gov/Education/Thermal/transfer.html

Convection Currents and Fire

Teacher Sheets

Pre-lesson Instructions

Review lab safety with students. Stress the need for safety particularly when students light the paper towels.

Background

Heat can be transferred from one place to another by three methods: conduction in solids, convection of fluids (liquids or gases), and radiation through anything that will allow radiation to pass. If there is a temperature difference in a system, heat will always move from higher to lower temperatures.

In liquids and gases, convection is usually the most efficient way to transfer heat. Convection occurs when warmer areas of a liquid or gas rise to cooler areas in the liquid or gas. As this happens, cooler liquid or gas takes the place of the warmer areas, which have risen higher. This cycle results in a continuous circulation pattern, and heat is transferred to cooler areas. You see convection when you boil water in a pan. The bubbles of water that rise are the hotter parts of the water rising to the cooler area of water at the top of the pan. You have probably heard the expression: "Hot air rises, and cool air falls to take its place." - This is a description of convection in our atmosphere. The circulation of the air transfers heat energy.

Simplified, convection is any flow that

1. picks up heat at one place,
2. transfers the heat to another place,
3. and is driven by this transport of heat.

Guidelines

1. Read the 9-12 NASAexplores article, “Preventing Fires On The Launch Pad,” and discuss the preventive measures taken to eliminate the risk of fire on the launch pad.
2. Divide students into groups of three to four.
3. Ask students to point out the location of the fire extinguisher, emergency shower, and fire blanket. Ask a student to explain how they are both used.
4. Remind students to tie back long hair, and push loose, long sleeves upward on their arms.
5. Remind students to wear safety goggles.

- Complete combustion activities in Microgravity — A Teacher's Guide — EG-1997-08-110-HQ
  http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Microgravity/Microgravity.Teachers.Guide.pdf

Convection Currents and Fire

Student Sheet(s)

Materials

- Large shoe box
- Candle
- Plastic wrap
- Scissors
- Two cardboard tubes
- Paper towels
- Fireplace matches
- Tape
- Clay

Background

Convection can be defined as the transmission of heat by the movement of heated gases. The heated gases from a burning substance move, forming a current. The most common fires caused by convection currents are those caused by the passage of heated gases to upper floors of buildings from a fire on the lower floor, and the passage of heated gases and embers from one burning building to another building.

Convection currents can be a major cause of a fire spreading. It is the presence of convection currents of heated gases that creates the possibility of "backdraft" and/or "mushrooming" of the fire within a burning building.

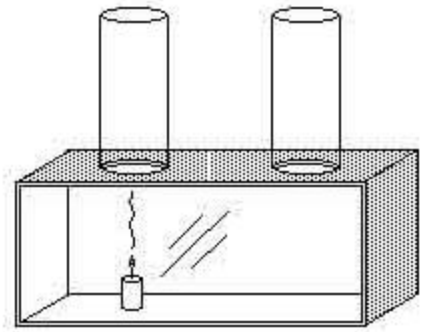
The hot, expanded gases that have become proportionately lighter will rise within a building giving off heat to all the objects they encounter. This rise of hot gases will continue vertically through all openings that will permit their passage, such as stairways, elevator shafts, dumbwaiters, nonfire stopped studding spaces, light wells, chutes, pipe holes, etc., until they are arrested. They will then build downward and/or spread horizontally.

All combustible material that has come in contact with the heated gases will be heated. If oxygen is absent, however, there will be no flame. The admission of air containing oxygen would cause these heated combustible gases or the heated combustible material to burn rapidly.

Procedure

1. Take the top off the shoe box and lay the box on its side.
2. Cut two holes the same size as the paper towel tube in the top side of the box (one at each end of the box).

3. Push the tubes into the holes, and seal the openings with tape to ensure it is airtight.
4. Set a candle in a clay base under one of the paper towel tube chimneys, pressing the clay firmly into place to hold it tight. The candle should be at least 2 inches lower than the chimney. Make sure the wick is exposed and upright.



5. Cover the open side of the box with clear plastic wrap. Tape the plastic wrap to the front of the box, forming an airtight seal.
6. Very CAREFULLY, using a fireplace match, light the candle by putting it down the chimney. Once the candle is lit, allow the box to warm up for approximately 5 minutes.
7. Roll a paper towel into a tight, coiled tube. Light one end of the paper towel, allow it to burn for about 10 seconds, extinguish it by blowing it out or shaking it rapidly. (Be careful!) It should be smoking profusely. Note that the smoke rises. Now, hold the smoldering paper down over the second chimney (without the candle). Record your observations.
8. Now hold the smoldering paper above the tube over the burning candle. Observe the movement of the smoke from the paper towel. Record your observations.
9. Remove the tape holding the plastic in place. Lift one corner of the plastic up. Place the smoldering paper towel near the opening. Observe the movement of the smoke. Record observations. Do not drop smoldering paper towels into the trash. Dampen the towel, and dispose of as directed by your teacher.
10. Prepare a sketch of your convection box. Using arrows, show the circulation of air through the box as observed in steps 7 through 9.

Questions

1. What, in nature, warms the air like the candle did in the experiment?
2. Why do forest fires sometimes produce high winds?
3. How does the formation of wind depend on convection currents?
4. Natural convection does not exist on the International Space Station, however fans are present for ventilation. How would this affect a fire on the International Space Station?
5. Write a hypothesis for how you think a candle will burn in microgravity.